# Transport variability along the subtropical Atlantic western boundary: Implications for monitoring the Meridional Overturning Circulation


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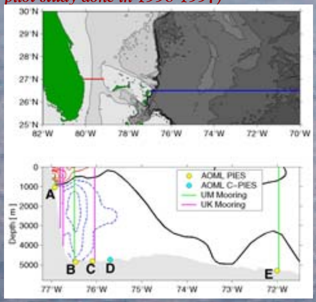
## 1. Components of the NOAA MOC monitoring system

*The NOAA OCO Western Boundary Time Series Project has three primary components:*

*•Florida Current monitoring via submarine cable (in place in a nearly continuous manner since 1982) and by hydrographic sections (4-5 CTD/LADCP sections and 8 dropsonde/XBT sections per year; sections were less frequent prior to 2001)*

*•Deep Western Boundary Current (DWBC) water mass monitoring via annual hydrographic cruises (done annually since 2001; less frequently back to 1985)*

*•DWBC transport monitoring using inverted echo sounders, deep pressure gauges, and a deep current meter (started in September 2004; pilot study done in 1996-1997)*

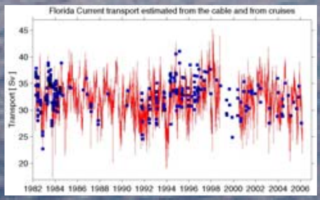



## 2. Florida Current Monitoring

*The Florida Current represents both the western boundary current for the subtropical Atlantic gyre as well as the pathway for the water in the upper limb of the Meridional Overturning Cell.*

*NOAA has been monitoring the Florida Current since 1982 through both continuous cable measurements and via hydrographic sections.*

*While there are strong variations (order 50%) of the Florida Current during the 20+ years of monitoring, there is no long-term trend in the time series to this point.*



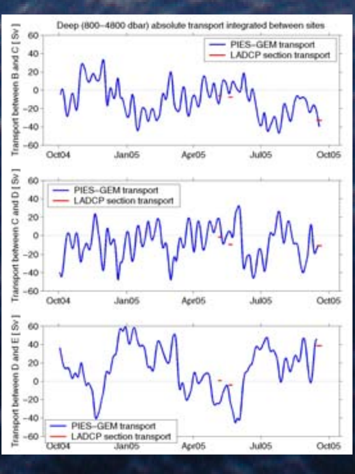

## 3. Monitoring the DWBC using Inverted Echo Sounders

*The newest component of the NOAA MOC observing system is the introduction of a line of Inverted Echo Sounders (IESs) to determine the daily variability of the transport of the DWBC. Some of the IESs include bottom pressure sensors (PIES), and one has an additional deep current meter (C-PIES). Deployed in September 2004, the data from these moored instruments are downloaded acoustically every six months during research cruises. The first year of data is shown in this poster. Transports are all integrated within 800—4800 dbar, essentially a simple estimate of the DWBC layer in this region. Sites A through E are denoted on the map and section plot above.*

## 4. Getting transports from PIES

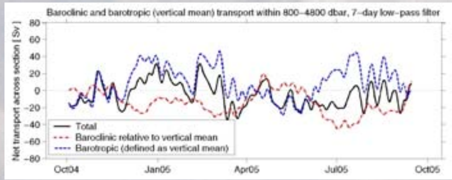
*Utilizing a technique called the Gravest Empirical Mode method, hydrographic data is combined with time series of IES travel times to yield profiles of temperature, salinity, and density on a daily basis at each of the IES sites. Density profiles can be vertically integrated to yield dynamic height anomaly profiles, and these profiles from neighboring IES sites can be differenced to give geostrophic velocities relative to an assumed level of no motion. When combined with bottom pressure differences from the PIES pressure sensors, the result is profiles of absolute velocity between PIES sites.*

*At right are the time series of absolute transports integrated between sites B and C (top), between C and D (middle), and between D and E (bottom); in all cases transport was integrated between 800—4800 dbars. Preliminary LADCP transports (courtesy L. Beal) integrated over the same spans from snapshot sections are shown in red.*

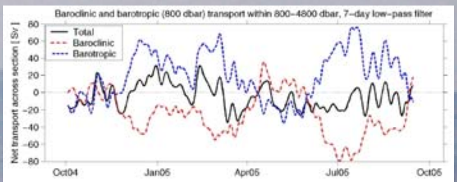



## 5. Baroclinic and barotropic DWBC transports

*Baroclinic and barotropic velocity components (the latter defined as the full-water-column vertical mean of the absolute velocity) can be determined between sites B and E. Baroclinic variability occurs primarily at time scales of one or more months, while the higher frequency variability is essentially all in the barotropic component.*



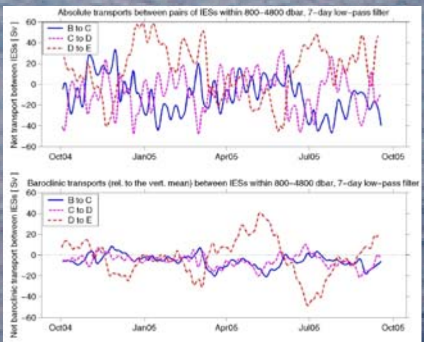

*If the baroclinic flow is instead defined relative to an assumed level of no motion at 800 dbars, as would commonly be done with a hydrographic section, then both the baroclinic and barotropic (the latter now defined as the 800 dbar velocity multiplied by the layer thickness) exhibit strong variability at longer and shorter time scales during the first year of data. This suggests that asynoptic problems with the baroclinic transports calculated from transbasin sections may be larger than has previously been suspected.*



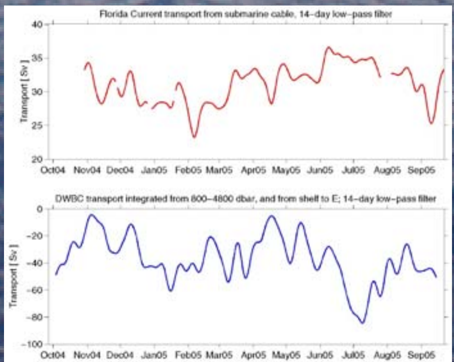

## 6. Timescales and "edge effects"

*The high frequency (7-15 days) barotropic transport fluctuations in the B-C span are often anticorrelated with those in the C-D span, while the lower frequencies may be uncorrelated. The barotropic transports in the D-E span are uncorrelated with the inshore flows at high frequencies, but they appear to be anticorrelated with the B-C transports at lower frequencies.*

*The baroclinic flows in the B-C and C-D spans are highly correlated, while the D-E baroclinic transports are generally negatively correlated with the inshore spans. Interestingly there are some high frequency (<21 days) strong (>20 Sv) baroclinic fluctuations in the inshore spans that do not appear to be correlated to the variations in the D-E span, suggesting that they may not be "edge effects" of the array.*




## 7. Components of the MOC




*Comparing the transport changes of the Florida Current (left, at top), which contains the majority of the upper limb of the MOC, and the fluctuations of the DWBC (left, at bottom), which contains the majority of the lower limb of the MOC, we see that the variations of the DWBC are much larger than those of the Florida Current during this period.*

*The mean Florida Current transport during this year (32 Sv) and the mean transport of the DWBC over this period (-37 Sv) are both essentially equal to the observed mean mass transports of these flows in the 1980s. If the one-year mean of data from the PIES array is representative of the modern period, which may not be the case, this would suggest that if there is a long-term change in the Atlantic MOC mass transport it must be occurring in the interior of the basin.*

## Preliminary conclusions

*•In the first year of data from the PIES line there is a high (~50%) level of variability in the DWBC at time scales ranging from a few days to a few months.*

*•This variability is in both the barotropic and the baroclinic components of the transport, although the barotropic flow tends to dominate the variability at time scales less than a few weeks.*

*•Not all of the baroclinic variability looks to be due to 'edge effects' of the array although additional work is needed to confirm this. There are strong, short-lived, baroclinic events which may lead to asynopticity problems for snapshot sections across the DWBC.*

*•The WBTS program is presently a contributing partner in an international effort to monitor the full basin-wide MOC at 26°N. There is a lot of interesting science that is going to come out of these MOC monitoring systems (WBTS, MOCHA, RAPID), and there is a lot of work ahead of us as we evaluate the different components of the system to determine how best to monitor the MOC over long timescales, in terms of accuracy, logistics and cost.*